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The acid-base condition in vegetation, litter and humus: II. Acids, acidoids and bases in relation to soil types.

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The following is a report on the composition of samples collected from the vegetation and humus layer on brown earth and podzol soil profiles, the object of the investigation being to determine the influence of the base status of the soil.

At the end of July 1937 samples were collected from the V, F and H layers of three brown earth and seven podzol profiles. A brief description is given in table 17. In July there is of course no fresh litter. There is therefore no F_0 samples in the collection.[1] The F_1 samples represent the surface layer and consists largely of leaves and needles from the last litter-fall. The V samples are shade leaves and needles except No 364 (spruce and pine) which were collected in an open stand. The F and H samples were collected at increasing depths in the order named (F_1 F_2 etc.) in layers where the material appeared different, usually 1—3 cm apart. Samples 363 and 357 are from hollow places in which leaves collect in the autumn. In samples 356 and 365 no green leaves were within reach.

The acid-base condition of the samples are shown in table 18 and were obtained as described in the first paper of this series. Besides the ordinary terms the following are here employed:

H = Capacity of original material to bind base (cf. fig. 10 A).

B = »Excess base» in the ashes by backward titration to methyl orange.

A = Capacity of electrodialysed material to bind base (cf. fig. 10 B).

pH_u = ultimate pH = pH of electrodialysed material.

It is obvious that the F_2, F_3 etc. samples of one profile cannot be compared with the corresponding samples of another since there may be little or no chronological relationship between them. The V

[1] Data for F_0 samples will be found in the first paper of this series. These samples were, however, not collected in any particular area in relation to the soil.

Table 17. *Description of the collected samples of vegetation (V), litter (F) and humus (H).*

Profile No	Name	Location	Soil type	Material	Thickness of humus layer, cm	pH in A-horizon	Samples collected
360	Pershög	Båstad	Brown earth	Beech leaves	<1	5.94	VF_1F_2
359	Varegården	Hallandsås	»	»	2	5.06	VF_1F_2
361	Pershög	Båstad	»	Spruce needles	<1	5.01	VF_1
356	Väderön	Kattegatt	Podzol	Beech leaves	10	4.06	F_1F_2H
363	Axelstorp	Hallandsås	»	»	20	3.80	$VF_1F_2F_3F_4F_5H_1H_2H_3H_4$
357	Tönnersjö	Halland	»	»	15	4.04	$VF_1F_2F_3H$
362	Varegården	Hallandsås	Podzolized	Spruce needles	6	3.83	VF_1F_2H
358	Tiohaga	»	Podzol	»	15	3.73	$VF_1F_2F_3H_1H_2$
365	Tönnersjö	Halland	»	»	7	3.65	$F_1F_2F_3F_4H$
364	Almasäng	Klevshult	»	»	8	3.64	V
364	»	»	»	Pine needles	8	3.64	V } F_1H[1]

and, in the case of leaves, the F samples are, however, comparable and show some very significant relationships.

Fig. 10 shows the titration curves of the V samples before and after electrodialysis, respectively. We note that the leaves and the spruce and pine needles form separate curve clusters, the relative position of which is reversed after electrodialysis: The more acidic needles contain less acidoids than the leaves and bind more base before than after electrodialysis.

At the end of table 18 the average values for the V and F_1 samples are given. The comparison may be summed up as follows:

1. The beech is not only higher in pH and bases but also in acidoids than spruce and pine.
2. The beech is lower than spruce and pine in acidity, in organic acids, in the acid/base ratio and in the pH_u values.
3. Pine is the least basic.

Regarding the influence of soil we note the following:

1. Beech grown on a brown earth having a high base status is not only higher in bases but also in acidoids and acids than beech

[1] Pine is the dominant tree.

Table 18. *The acid-base data of the material described in table 17.*

No	Sample	Loss on ignition %	pH	M.e./100 g. loss on ignition: Acidity H	Bases B	Acidoids A	Org. acids H+B−A=a	$\frac{H+B}{B}$ $\left(=\frac{A+a}{B}\right)$	pH_u in: water w	N. KCl s	w—s
	Brown earth:					Beech:					
360	V	94.10	6.25	13.0	111.8	65.7	59.1	1.12	3.20	2.82	0.38
»	F_1	91.11	5.67	23.5	122.8	98.0	48.3	1.19	2.94	2.25	0.69
»	F_2	70.80	5.96	27.0	159.7	149.0	37.7	1.17	2.99	2.19	0.80
359	V	94.11	6.17	14.0	113.3	70.0	57.3	1.12	3.18	2.88	0.30
»	F_1	91.44	5.22	35.5	101.6	100.7	36.4	1.35	3.03	2.24	0.79
»	F_2	50.15	5.54	33.5	151.5	97.0	88.0	1.22	3.27	2.56	0.71
						Spruce:					
361	V	95.35	4.41	27.0	71.5	26.1	72.4	1.38	3.34	3.12	0.22
»	F_1	81.10	5.21	26.5	128.7	68.3	86.9	1.21	3.04	2.45	0.59
	Podzol:					Beech:					
356	F_1	91.55	5.12	44.5	68.3	95.0	17.8	1.65	3.03	2.26	0.77
»	F_2	90.27	4.31	69.0	49.7	99.5	19.2	2.39	3.05	2.18	0.87
»	H	79.94	3.49	119.0	35.8	132.0	22.8	4.32	3.06	2.06	1.00
363	V	93.99	6.18	15.2	89.9	57.3	47.8	1.17	3.24	2.87	0.37
»	F_1	94.23	5.19	30.7	64.8	78.8	16.7	1.47	3.06	2.33	0.73
»	F_2	91.42	5.50	30.0	71.4	93.0	8.4	1.42	2.99	2.32	0.67
»	F_3	90.22	5.20	40.0	72.4	100.6	11.8	1.55	3.04	2.26	0.78
»	F_4	88.66	3.76	91.5	29.8	124.0	—2.7	4.07	3.05	2.16	0.89
»	F_5	82.49	3.51	117.0	25.0	131.5	10.5	5.68	3.01	2.12	0.89
»	H_1	65.84	3.49	118.5	24.3	150.0	—7.2	5.88	3.11	2.20	0.91
»	H_2	50.67	3.57	128.2	19.9	146.6	1.5	7.44	3.21	2.34	0.87
»	H_3	67.35	3.42	144.0	24.2	153.5	14.7	6.95	3.07	2.25	0.82
»	H_4	39.28	3.59	134.0	28.8	148.5	14.3	5.65	3.24	2.44	0.80
357	V	94.84	6.02	12.0	78.3	51.5	38.8	1.15	3.13	2.81	0.32
»	F_1	93.18	5.21	32.2	73.1	91.0	14.3	1.44	3.13	2.35	0.78
»	F_2	86.64	5.71	28.0	78.7	98.8	7.9	1.36	3.12	2.30	0.82
»	F_3	67.95	5.14	46.5	49.0	91.5	4.0	1.95	3.20	2.43	0.77
»	H	34.80	4.34	77.2	34.2	101.0	10.4	3.26	3.38	2.62	0.76
	Podzol:					Spruce:					
362	V	95.66	4.08	43.8	43.2	26.0	61.0	2.01	3.47	3.26	0.21
»	F_1	92.46	5.34	30.0	62.8	63.7	29.1	1.48	3.21	2.58	0.63
»	F_2	92.28	4.40	48.0	32.6	59.3	21.3	2.47	3.18	2.53	0.65
»	H	81.00	3.74	97.5	24.9	117.5	4.9	4.92	3.08	2.29	0.79
358	V	96.98	3.99	40.0	34.9	26.0	48.9	2.15	3.43	—	—
»	F_1	94.31	5.25	23.0	57.4	40.0	40.4	1.40	3.37	2.79	0.58
»	F_2	88.88	4.53	57.6	42.3	92.0	7.9	2.36	3.07	2.36	0.71
»	F_3	85.30	4.05	79.2	33.6	119.0	—6.2	3.36	3.06	2.22	0.84
»	H_1	88.62	3.62	122.5	31.1	145.5	8.1	4.94	3.01	2.08	0.93
»	H_2	88.27	3.63	131.0	23.8	148.0	6.8	6.50	3.11	2.23	0.88
365	F_1	93.93	4.11	54.0	52.7	56.6	50.1	2.02	3.12	2.38	0.74
»	F_2	91.04	4.30	60.5	31.1	84.5	7.1	2.95	3.09	2.34	0.75
»	F_3	88.66	3.87	75.5	24.7	95.7	4.5	4.06	3.06	2.26	0.80

Table 18 continued.

No	Sample	Loss on ignition %	pH	M.e./100 g. loss on ignition: Acidity H	Bases B	Acidoids A	Org. acids H+B−A=a	$\frac{H+B}{B}$ $\left(=\frac{A+a}{B}\right)$	pH_u in: water w	N.KCl s	w—s
365	F_4	89.80	3.64	87.0	24.3	105.5	5.8	4.58	2.91	2.10	0.81
»	H	72.22	3.56	93.0	26.8	139.5	—19.7	4.47	2.93	2.07	0.86
364	V	94.94	3.84	46.0	60.4	36.7	69.7	1.76	3.19	2.81	0.38
					Pine:						
364	V	97.48	3.87	50.5	33.5	34.2	49.8	2.51	3.30	2.49	0.81
»	F_1	80.94	4.11	71.0	28.2	95.0	4.2	3.52	3.20	2.44	0.76
»	H	86.12	3.48	121.3	19.7	137.7	3.3	7.16	2.98	2.13	0.85
	Average for brown earth:										
Beech	V		6.21	13.5	112.6	67.9	58.2	1.12	3.19	2.85	0.34
»	F_1		5.45	29.5	112.2	99.4	42.4	1.27	2.99	2.25	0.74
	Average for podzol:										
Beech	V		6.10	13.6	84.1	54.4	43.3	1.16	3.19	2.84	0.35
»	F_1		5.17	35.8	68.7	88.3	16.3	1.52	3.07	2.31	0.76
Spruce	V		3.97	43.3	46.2	29.6	59.9	1.97	3.36	3.04	0.30
»	F_1		4.90	35.7	57.6	53.4	39.7	1.63	3.23	2.58	0.65

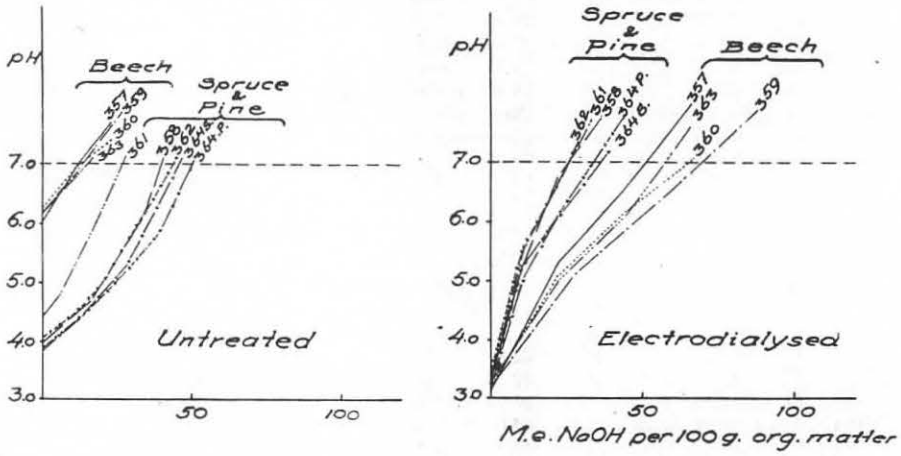

Fig. 10. Titration curves of the (green) V samples before and after electrodialysis.

grown on a podzol. In the V samples of beech there is little or no difference in pH and acidity, a small difference in the acid/base ratio and apparently no difference in the pH_u values.

2. The spruce grown on the brown earth has a higher pH, is higher in bases and acids, is lower in acidity and in the acid/base ratio than spruce grown on podzol. But the spruce grown on the brown earth is less basic than the beech grown on the podzol (true for V samples only). As in the case of beech the pH_u values seem to be unaffected by the soil. These values are related to the acidoid content (cf. fig. 11).

Spruce no 364 is from a poor stand on a sandy soil noted by Tamm as one of the poorest in Sweden. Yet it contains more bases (and acids) than

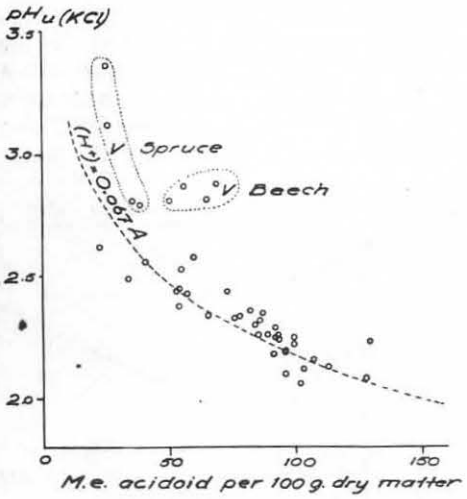

Fig. 11. The relationship between the $pH_{u(KCl)}$ values and the acidoid content.

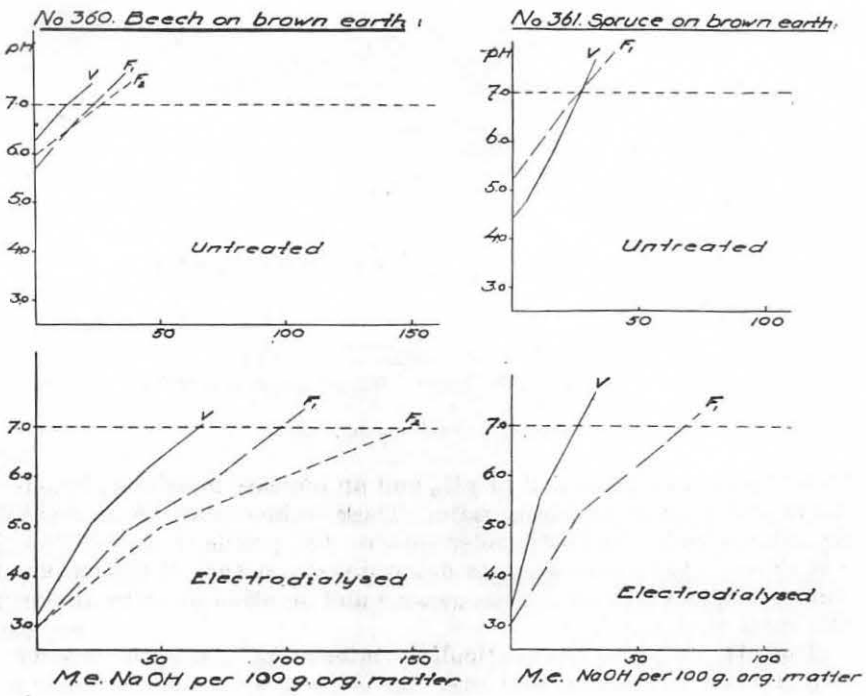

Fig. 12 and 13. Titration curves of samples described in tables 17 and 18.

the other two podzol V samples of spruce. This might be due to a difference in variety or it might be due to a difference in exposure to the sun, all others being shade samples.

A comparison of the deeper humus layers (of which there are none in the brown earth profiles) shows no characteristic differences between beech and spruce. In both there is a decrease in pH, in

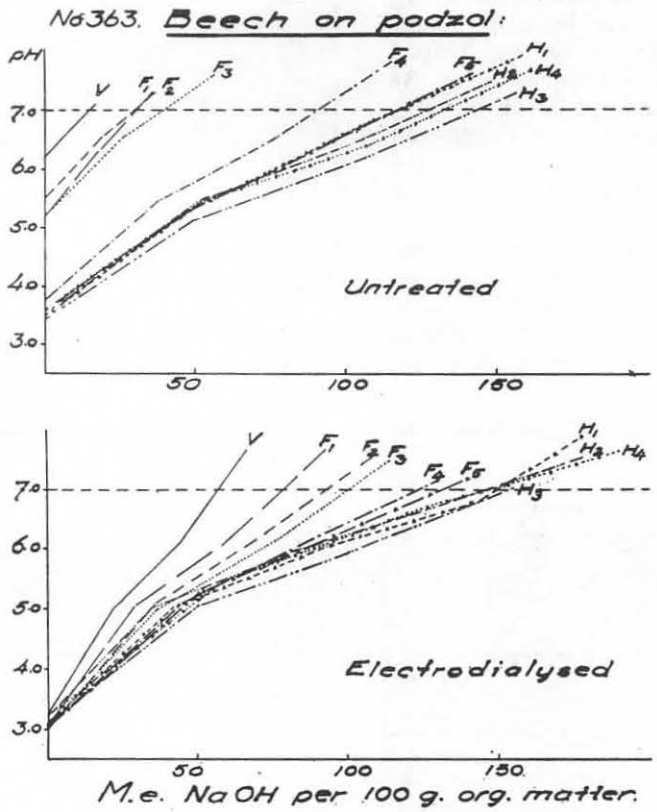

Fig. 14. Same as fig. 13.

bases, in organic acids and in pH_u and an increase in acidity, in acidoids and in the acid/base ratio. These values may be as small or as large under beech as under spruce. The profile characteristics, not those of the plant, seem to determine the nature of the mature humus layer. Of these the base status and aeration must be among the most important.

The pH_u in N. KCl is particularly interesting. As in the case of our laboratory experimental material there is a linear relationship

between the H ion activity of the F and H samples in KCl solution and their acidoid content. This is shown in fig. 11. (The curve from the equation $(H^+) = 0.067\ A$ will be discussed later in a special paper on the strength of acidoids.) As in our previous work

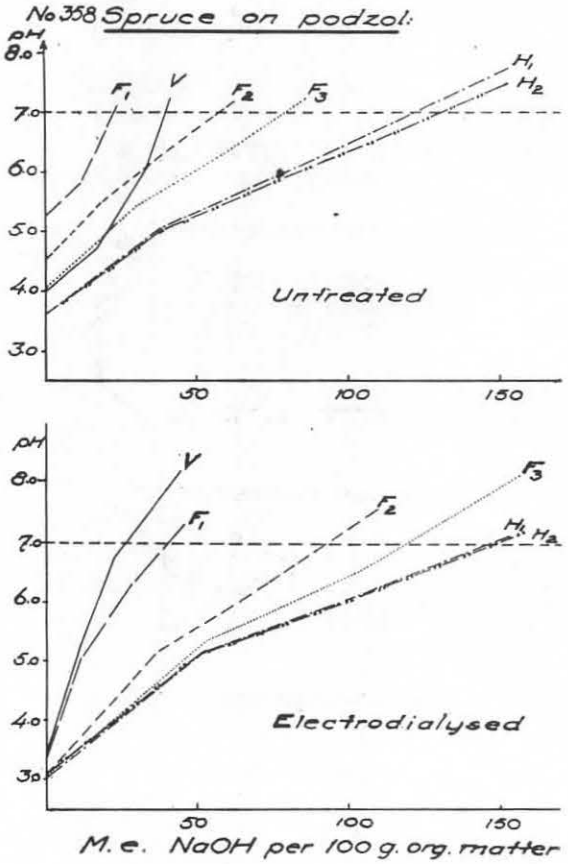

Fig. 15. Same as fig. 12.

the V samples do not show the same relationship but have a higher pH_u, as if they contained a greater proportion of basic nitrogen. This is in agreement with the two to three times lower exchange acidity (w—s in table 18) of the V as compared to that of the F and H samples.

It will be noted that the pH_{uKCl} values in some of the H layers (cf. No 363 and 357) show a tendency to increase again. These

samples are all high in ash constituents whose sesquioxides yield a complex having a higher I.E.P. and therefore a higher pH_u.

The relationship between the various other factors within each

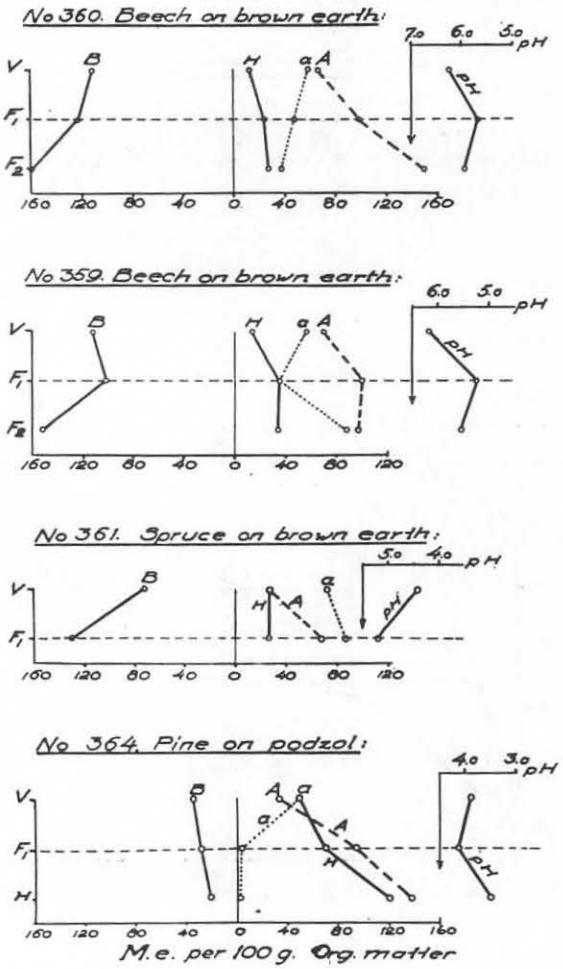
No 360. Beech on brown earth:
No 359. Beech on brown earth:
No 361. Spruce on brown earth:
No 364. Pine on podzol:
M.e. per 100 g. Org. matter

Fig. 16. The acid-base condition in the organic layers of the profiles described in tables 17 and 18.

profile is best shown graphically. Fig. 12 and 13 show the titration curves for beech and spruce on brown earth respectively and fig. 14 and 15 show the titration curves for the same species on podzol. The curves representing the original material give, at pH 7, the acidity or H values in table 18. The curves representing the electro-

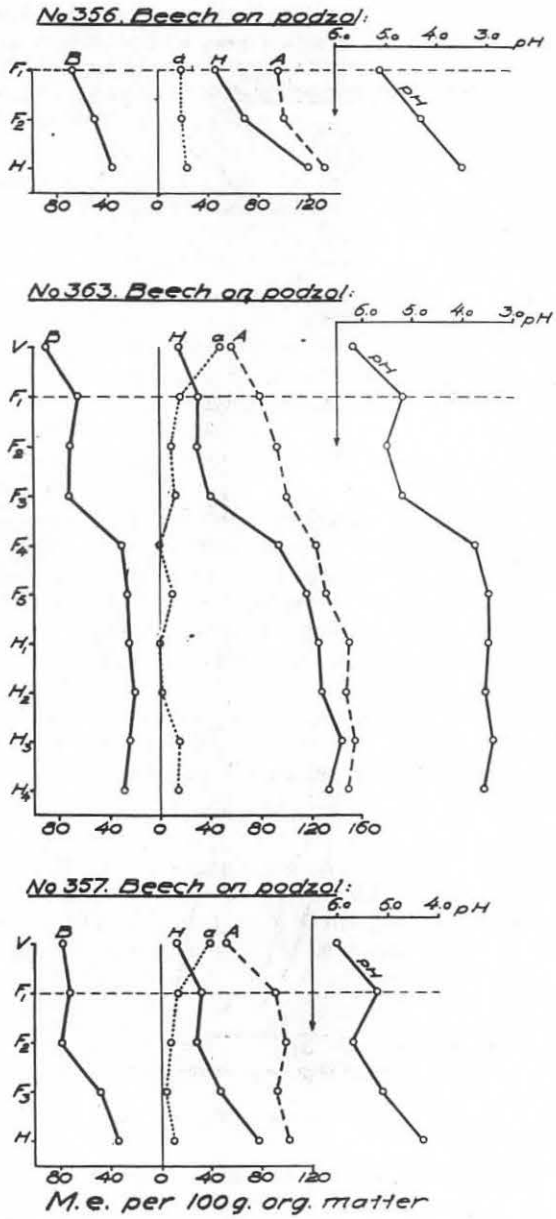

Fig. 17. Same as fig. 16.

dialysed material give, at pH 7, the acidoid or A values in the table. These curves may be taken as representatives for the plant species and soil types here studied and will therefore make it un-

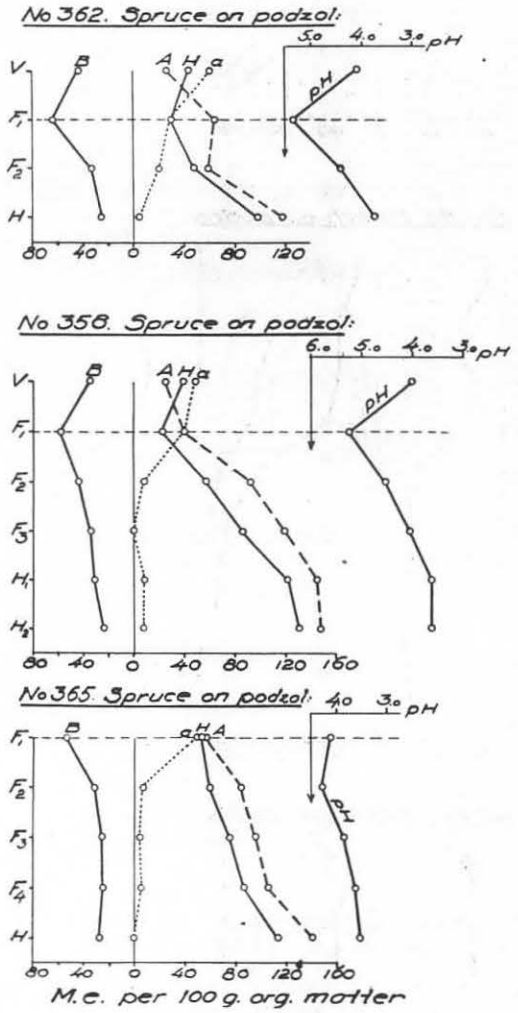

Fig. 18. Same as fig. 16.

necessary to reproduce all the corresponding curves of the other profiles.

We note first of all that the position of the titration curves, which is irregular in the original samples, assumes a definite order

in the case of the electrodialysed samples. The latter show a steady increase in the capacity to bind base, i.e., in acidoid content, from that of the green leaves or needles to that of the amorphous humus. The acidoid content is over twice as great in green beech leaves as in green spruce needles but in the »mature» humus it is about the same in both species. The curves representing the untreated samples show how the acidity and the unsaturation with bases increases as the humification progresses in the podzol profiles.

Figures 16 to 18 show the acid-base conditions in the organic layers with respect to pH, acidity, bases, acidoids and acids of all the profiles here studied. The ordinates give the layers in the order in which they occur in nature without reference to depth, and the abscissa the number of milliequivalents of acid or base per 100 grams loss on ignition. The pH is inserted on a separate abscissa.

The curves bring out the relationships more clearly than the figures in table 18. The most outstanding facts are the following:

1. The three curves representing bases, acidity and pH are mostly of the same pattern, running in general approximately parallel to each other.
2. The organic acids decrease downwards in all the profiles having a low base status, i.e., the podzols. In the brown earths the organic acids are high in the F layers as well as in V. Their accumulation is always accompanied by an increase in bases.
3. There is a general downward increase in acidoids.
4. The beech has a pH minimum in F_1 whereas spruce and pine have maxima in this layer.
5. The F layers in the brown earths are richer in bases than the F layers in the podzols.

Summary.

The organic layers of three brown earths and seven podzols have been examined with respect to pH, acidity, bases, acidoids, organic acids, ultimate pH and exchange acidity. The vegetation includes beech and spruce and one sample of pine.

(MS. received June 10th 1940.)